Quantum and non-signalling graph isomorphisms

We introduce the (G,H)-isomorphism game, a new two-player non-local game that classical players can win with certainty iff the graphs G and H are isomorphic. We then define quantum and non-signalling isomorphisms by considering perfect quantum and non-signalling strategies for this game. We prove that non-signalling isomorphism coincides with fractional isomorphism, giving the latter an operational interpretation. We show that quantum isomorphism is equivalent to the feasibility of two polynomial systems obtained by relaxing standard integer programs for graph isomorphism to Hermitian variables. Finally, we provide a reduction from linear binary constraint system games to isomorphism games. This reduction provides examples of quantum isomorphic graphs that are not isomorphic, implies that the tensor product and commuting operator frameworks result in different notions of quantum isomorphism, and proves that both relations are undecidable.

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